MILITARY SPECIFICATION

CAPACITORS, CHIP, FIXED, TANTALUM, ESTABLISHED RELIABILITY, GENERAL SPECIFICATION FOR

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers the general requirements for established reliability, tantalum, fixed, chip capacitors, primarily intended for use in thick and thin film hybrid circuits for filter, bypass, coupling, and other applications where the alternating current (ac) component is small compared to the direct current (dc) rated voltage and where supplemental moisture protection is available (see 6.1). These capacitors have reliability ratings established on the basis of life tests performed at specified voltage at +85°C for failure rate (FR) levels ranging from:

a. 1.0 percent per 1,000 hours to 0.001 percent per 1,000 hours in accordance with MIL-STD-690. These FR levels are established at a 60-percent confidence level and are maintained at a 10-percent producer's risk (Exponential distribution).

b. 0.1 percent per 1,000 hours to 0.0001 percent per 1,000 hours (1 FIT) 1/ at a 90-percent confidence level (Weibull distribution).

1.2 Classification. Capacitors covered by this specification are classified by the style, as specified (see 3.1).

1.2.1 Type designation. The type designation shall be in the following form, and as specified (see 3.1).

CWR06	B	A	225	J	M
Style (1.2.1.1)	Voltage (1.2.1.2)	Termination finish (1.2.1.3)	Capacitance (1.2.1.4)	Capacitance tolerance (1.2.1.5)	FR level (1.2.1.6)

1.2.1.1 Style. The style is identified by the three-letter symbol "CWR", followed by a two-digit number; the letters identify established reliability, tantalum, fixed, chip capacitors, and the number identifies the design of the capacitor.

1.2.1.2 Voltage. The voltage (rated, derated, and surge) is identified by a single letter as shown in table I.

1/ FIT = failure unit = one failure per 10^9 device hours.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: US Army Laboratory Command, Fort Monmouth, NJ 07703-5302, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of document or by letter.

AMSC N/A FSC 5910

TABLE I. Voltage.

Symbol	Voltage		
	Rated (+85°C)	Derated (+125°C)	Surge (+85°C)
	Volts, dc	Volts, dc	Volts, dc
A	2	1.3	2.6
B	3	2.0	4.0
C	4	2.7	5.0
D	6	4.0	8.0
E	8	5.4	10.0
F	10	7.0	13.0
G	12	8.0	16.0
H	15	10.0	20.0
J	20	13.0	26.0
K	25	17.0	32.0
L	30	20.0	39.0
M	35	23.0	46.0
N	50	33.0	65.0

1.2.1.3 Termination finish. The termination finish is identified by a single letter, as follows:

A - - - - - - - - - - - Solder-coated nickel
B - - - - - - - - - - - Gold
C - - - - - - - - - - - Solder-coated gold
D - - - - - - - - - - - Solder-coated alloy 725

1.2.1.4 Capacitance. The nominal capacitance value, expressed in picofarads (pF), is identified by a three-digit number; the first two digits represent significant figures and the last digit specifies the number of zeros to follow.

1.2.1.5 Capacitance tolerance. The capacitance tolerance is identified by a single letter as shown in table II.

TABLE II. Capacitance tolerance.

Symbol	Capacitance tolerance
	Percent (±)
J	5
K	10
M	20

1.2.1.6 Failure rate (FR) level. The FR level (based on life tests performed at specified voltage) is identified by a single letter as shown in table III.

TABLE III. FR level.

Symbol	Exponential FR level 60% confidence level - unit hours totaled from several lots.
	% per 1,000 hrs
M	1.0
P	0.1
R	0.01
S	0.001
	Weibull FR level 90% confidence level - unit hours total per each lot
	% per 1,000 hrs
B	0.1
C	0.01
D	0.001
E	0.0001

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications and standards. The following specifications and standards form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of these documents shall be those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation.

SPECIFICATIONS

FEDERAL

QQ-S-571 - Solder, Tin Alloy: Tin-Lead Alloy; and Lead Alloy.

MILITARY

MIL-C-39028 - Capacitors, Packaging of.
MIL-C-55365/2 - Capacitors, Chip, Fixed, Tantalum, Established Reliability, Styles CWR03 and CWR04.
MIL-C-55365/4 - Capacitors, Chip, Fixed, Tantalum, Established Reliability, Styles CWR06 and CWR09.
MIL-C-55365/7 - Capacitors, Chip, Fixed, Tantalum, Established Reliability, Style CWR10.
DOD-C-55365/8 - Capacitors, Chip, Fixed, Tantalum, Established Reliability, Style CWR11.

STANDARDS

MILITARY

MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes.
MIL-STD-202 - Test Methods for Electronic and Electrical Component Parts.
MIL-STD-690 - Failure Rate Sampling Plans and Procedures.

MIL-STD-790 - Reliability Assurance Program for Electronic Parts Specifications.
MIL-STD-1276 - Leads, Weldable, For Electronic Component Parts.
MIL-STD-1285 - Marking of Electrical and Electronic Parts.

(Copies of the specifications and standards required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting activity.)

2.2 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein (except for associated detail specifications, specification sheets or MS standards), the text of this specification shall take precedence. Nothing in this specification, however, shall supersede applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Specification sheets. The individual item requirements shall be as specified herein and in accordance with the applicable specification sheets. In the event of any conflict between requirements of this specification and the specification sheets, the latter shall govern (see 6.2).

3.2 Qualification. Capacitors furnished under this specification shall be products which are qualified for listing on the applicable qualified products list at the time set for opening of bids (see 4.4 and 6.3). Unless acquired from the manufacturer or his authorized distributor listed or approved for listing on the qualified products list, parts furnished under this specification shall not be considered as having met the requirements of this specification.

3.3 Reliability. Reliability of capacitors furnished under this specification shall be established and maintained in accordance with the procedures and requirements specified in MIL-STD-790 and MIL-STD-690 with details specified in 4.1.1, 4.4.4, and 4.5. The reliability rating is identified by the following FR level symbols:

Symbol	Exponential FR level (% per 1,000 hrs)	Symbol	Weibull FR level (% per 1,000 hrs)
M	1.0	B	0.1
P	0.1	C	0.01
R	0.01	D	0.001
S	0.001	E	0.0001 (1 FIT)

3.4 Materials. Materials shall be as specified herein. However, when a definite material is not specified, a material shall be used which will enable the capacitors to meet the performance requirements of this specification. Acceptance or approval of any constituent material shall not be construed as a guaranty of the acceptance of the finished product.

3.5 Design and construction. Capacitors shall be of the design, construction, and physical dimensions specified (see 3.1).

3.5.1 Body structure. The body structure shall be either of the encapsulated or unencapsulated form (see 3.1).

3.5.2 Terminals. Terminals shall be of a solid conductor, of the dimensions specified (see 3.1), and, except for style CWR05, shall be suitably treated to facilitate soldering. When specified (see 3.1), terminals shall conform to type W3 of MIL-STD-1276.

3.6 Voltage aging (exponential only). When tested as specified in 4.7.3, capacitors shall meet the following requirements:

DC leakage - - - - - - - - - Shall not exceed the requirement specified in 3.7.
Capacitance- - - - - - - - - Shall be within the tolerance specified (see 3.1).
Dissipation factor - - - - - Shall not exceed the requirement specified in 3.9.

3.7 DC leakage. When measured as specified in 4.7.4, the dc leakage shall not exceed the applicable value specified (see 3.1).

3.8 Capacitance. When measured as specified in 4.7.5, the capacitance shall be within the applicable tolerance specified (see 3.1).

3.9 Dissipation factor. When measured as specified in 4.7.6, the dissipation factor shall not exceed the value specified (see 3.1).

3.10 Vibration, high frequency. When capacitors are tested as specified in 4.7.7, there shall be no intermittent contacts of 0.5 millisecond (ms) or greater duration, or arcing or other indication of breakdown, nor shall there be any open- or short-circuiting or evidence of mechanical damage.

3.11 Thermal shock. When tested as specified in 4.7.8, capacitors shall meet the following requirements:

DC leakage - - - - - - - -	Shall not exceed the requirement specified in 3.7.
Capacitance- - - - - - - -	Shall change not more than ±5 percent from the initial measured value.
Dissipation factor - - - -	Shall not exceed the requirement specified in 3.9.
Visual examination - - - -	There shall be no evidence of harmful corrosion, mechanical damage, or obliteration of marking (if applicable).

3.12 Resistance to soldering heat. When capacitors are tested as specified in 4.7.9, there shall be no evidence of mechanical damage.

3.13 Terminal strength (when specified, see 3.1). When capacitors are tested as specified in 4.7.10, there shall be no loosening of the terminals or permanent damage to the terminals.

3.14 Moisture resistance. When tested as specified in 4.7.11, capacitors shall meet the following requirements:

DC leakage - - - - - - - -	Shall not exceed 200 percent of tne requirement specified in 3.7.
Capacitance- - - - - - - -	Shall change not more than ±15 percent from the initial measured value.
Dissipation factor - - - -	Shall not exceed 150 percent of the requirement specified in 3.9.
Visual examination - - - -	There shall be no evidence of harmful corrosion, mechanical damage, or obliteration of marking (if applicable).

3.15 Stability at low and high temperatures. When tested as specified in 4.7.12, capacitors shall meet the following requirements:

Step 1 (+25°C):

DC leakage - - - - - - -	Shall not exceed the applicable value specified (see 3.1).
Capacitance- - - - - - -	Shall be within tolerance of the nominal value specified (see 3.1).
Dissipation factor - - -	Shall not exceed the applicable value specified (see 3.1).

Step 2 (-55°C):

Capacitance- - - - - - -	Shall change not more than the applicable value specified (see 3.1) from the step 1 measured value.
Dissipation factor - - -	Shall not exceed the applicable value specified (see 3.1).

Step 3 (+25°C):

DC leakage - - - - - - -	Shall not exceed the applicable value specified (see 3.1).
Capacitance- - - - - - -	Shall change not more than ±5 percent from the step 1 measured value.
Dissipation factor - - -	Shall not exceed tne requirement specified in 3.9.

Step 4 (+85°C):

DC leakage	Shall not exceed the applicable value specified (see 3.1).
Capacitance	Shall change not more than the applicable value specified (see 3.1) from the step 1 measured value.
Dissipation factor	Shall not exceed the requirement specified in 3.9.

Step 5 (+125°C):

DC leakage	Shall not exceed the applicable value specified (see 3.1).
Capacitance	Shall change not more than the applicable value specified (see 3.1) from the step 1 measured value.
Dissipation factor	Shall not exceed the applicable value specified (see 3.1).

Step 6 (+25°C):

DC leakage	Shall not exceed the applicable value specified (see 3.1).
Capacitance	Shall change not more than the applicable value specified (see 3.1) from the step 1 measured value.
Dissipation factor	Shall not exceed the requirement specified in 3.9.

3.16 Surge voltage (exponential only, see 3.1). When tested as specified in 4.7.13, capacitors shall meet the following requirements:

DC leakage	Shall not exceed the requirement specified in 3.7.
Capacitance	Shall change not more than the applicable value specified (see 3.1) from the initial measured value.
Dissipation factor	Shall not exceed the requirement specified in 3.9.

3.17 Life (exponential only, see 3.1). When capacitors are tested as specified in 4.7.14, there shall be no evidence of harmful corrosion, or obliteration of marking (if applicable) mechanical damage, intermittent shorts, or permanent shorts or opens.

3.17.1 Qualification inspection. When tested as specified in 4.7.14, capacitors shall meet the following requirements:

At +25°C:

DC leakage	Shall not exceed the applicable value specified (see 3.1).
Capacitance	Shall change not more than the applicable value specified (see 3.1) from the value obtained when measured as specified in 4.7.5.
Dissipation factor	Shall not exceed the applicable value specified (see 3.1).

At +85°C:

DC leakage	Shall not exceed the applicable value specified (see 3.1).

At +125°C:

DC leakage	Shall not exceed the applicable value specified (see 3.1).

3.17.2 Quality conformance inspection.

3.17.2.1 For group A inspection. When tested as specified in 4.7.3 or 4.7.17, exponential or Weibull as applicable, capacitors shall meet the requirements specified in 3.6 or 3.20. Weibull FR level grading data from the inspection lot that meets the requirements of 4.7.17 and 3.20 shall be accepted in lieu of group B inspection data.

3.17.2.2 For group C life or extended life (see 4.7.14.1). When tested as specified in 4.7.14, capacitors shall meet the following requirements:

At +25°C:

DC leakage - - - - - - -	Shall not exceed the applicable value specified (see 3.1).
Capacitance- - - - - - -	Shall change not more than ±10 percent from the value obtained when measured as specified in 4.7.5.
Dissipation factor - - -	Shall not exceed the applicable value specified (see 3.1).

At +85°C:

DC leakage - - - - - - -	Shall not exceed the applicable value specified (see 3.1).

At +125°C:

DC leakage - - - - - - -	Shall not exceed the applicable value specified (see 3.1).

3.18 Solderability. When capacitors are tested as specified in 4.7.15, the immersed metallized mounting surface or terminations shall be at least 75 percent covered with a smooth solder coating and shall exhibit no demetallization or leaching of the terminal ends. The remaining 25 percent may contain only small pinholes or rough spots, these shall not be concentrated in one area. In case of dispute, the percentage of coverage with pinholes or rough spots shall be determined by actual measurement of these areas, as compared to the total area.

3.19 Resistance to solvents. When tested as specified in 4.7.16, marking shall remain legible and shall not smear, and capacitors shall meet the following requirements:

DC leakage - - - - - - - -	Shall not exceed the requirement specified in 3.7.
Capacitance- - - - - - - -	Shall change not more than ±2 percent from the initial measured value.
Dissipation factor - - - -	Shall not exceed the requirement specified in 3.9.

3.20 Weibull FR level grading (in lieu of 3.6). When tested as specified in 4.7.17, capacitors shall exhibit decreasing failure rate with respect to time as evidenced by a value of beta (β) which is less than one; and the instantaneous failure rate in the last interval shall be no more than the failure rate specified. After grading, capacitors shall meet the following requirements:

DC leakage - - - - - - - -	Shall not exceed the requirement specified in 3.7.
Capacitance- - - - - - - -	Shall be within the tolerance specified (see 3.1).
Dissipation factor - - - -	Shall not exceed the requirement specified in 3.9.

Capacitors tested as specified in 4.7.17 shall be exempt from group A percent defective allowable (PDA) provisions (4.6.1.2) and exempt from 3.17.2.2 extended life (4.7.14.1).

3.21 Marking. Styles CWR03 and CWR04 capacitors shall be marked in accordance with method I of MIL-STD-1285, and shall be as specified (see 3.1). All styles shall have the following information marked on the package.

a. "JAN" brand.

b. Rated capacitance.

c. Rated voltage.

d. Capacitance tolerance.

e. Failure rate level symbol.

f. Type designation.

g. Manufacturer's source code per MIL-STD-1285.

Polarity marking shall be as specified (see 3.1).

3.21.1 "JAN" and "J" marking. The United States Government has adopted, and is exercising legitimate control over, the certification marks "JAN" and "J" respectively, to indicate electrical equipment, namely, resistors, capacitors, electron tubes and the like, acquired by, or manufactured for use by, or for the Government in accordance with standard Government specifications. Accordingly, capacitors acquired to, and meeting all of, the criteria specified herein and in applicable specification sheets shall bear the certification mark "JAN", except that capacitors too small to bear the certification mark "JAN" shall bear the letter "J". Capacitors furnished under contracts or orders which either permit or require deviation from the conditions or requirements specified herein and in applicable specification sheets shall not bear "JAN" or "J". In the event a capacitor sample fails to meet the requirements of this specification and the applicable specification sheet, the manufacturer shall remove the "JAN" or "J" from the sample tested and also from all capacitors represented by the sample. The United States Government has obtained Certificate of Registration No. 504,860 for the certification mark "JAN".

3.22 Workmanship. Capacitors shall be processed in such a manner, that when examined under 10X magnification, they shall be uniform in quality and shall be free from pits, cracks, rough edges, and other defects that will affect life, serviceability, or function. The capacitors shall exhibit no demetallization (lift-off) on the terminations.

3.22.1 Soldering. All excess flux or solder shall be removed. Electrical connections shall be electrically continuous after soldering.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or purchase order, the supplier may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1 Reliability assurance program. A reliability assurance program shall be established and maintained in accordance with MIL-STD-790. Evidence of such compliance shall be verified by the qualifying activity of this specification as a prerequisite for qualification and continued qualification.

4.2 Classification of inspections. The inspections specified herein are classified as follows:

a. Qualification inspection (see 4.4).

b. Verification of qualification (see 4.5).

c. Quality conformance inspection (see 4.6).

4.3 Inspection conditions and methods.

4.3.1 Conditions. Unless otherwise specified herein, all inspections shall be performed in accordance with the test conditions specified in the "GENERAL REQUIREMENTS" of MIL-STD-202.

4.3.2 Methods.

4.3.2.1 AC measurements. AC measurements shall be made at the frequency specified. The magnitude of the ac voltage shall be equal to or less than 1.0 volt root mean square (rms). The maximum dc bias voltage shall be equal to or less than 2.2 volts.

4.3.2.2 Reference measurements. When requirements are based on comparative measurements made before and after conditioning, the reference measurement shall be considered the last measurement made at 25° ±5°C prior to conditioning. Unless reference measurements have been made within 30 days prior to the beginning of conditioning, they shall be repeated.

4.3.3 Power supply. The power supply used for life testing shall have a regulation of ±2 percent or less of the rated voltage. The power source employed for dc leakage current measurements shall be stabilized to at least ±100 parts per million. During measurements there must be no voltage fluctuations of sufficient amplitude to produce a variation in the current measurement as read with any dc leakage current tester used to test capacitors.

4.4 Qualification inspection. Qualification inspection shall be performed at a laboratory acceptable to the Government (see 6.3) on sample units produced with equipment and procedures normally used in production. Qualification approval will be based on the successful completion of the tests specified in table IV, and will not be withheld pending completion of the extended life test of 4.4.4.1a.

4.4.1 Sample size. The number and style combinations of capacitors to be subjected to qualification inspection shall be as specified in the appendices to this specification.

4.4.2 Inspection routine. The sample shall be subjected to the inspections specified in table IV, in the order shown. All sample units shall be subjected to the inspections of group I. The units successfully completing group I inspection shall then be divided as specified in table IV for groups II through VI (or VII) inclusive, and subjected to the inspections for their particular group; for combined voltage group submissions, each type shall be equally represented in each group (see 4.6.1.1).

4.4.3 Failures. Failures in excess of those allowed in table IV shall be cause for refusal to grant qualification approval.

4.4.4 FR qualification.

4.4.4.1 Exponential. Exponential FR qualification shall be in accordance with the general and detailed requirements of MIL-STD-690 and the following details:

a. Procedure I - Qualification at the initial FR level. FR level M of FRSP-60 shall apply. Sample units shall be subjected to the qualification inspection specified in group VI, table IV (see 4.4.2). The entire life test sample shall be continued on test to 10,000 hours as specified in 4.7.14.1 upon completion of the 2,000-hour qualification test.

b. Procedure II - Extension of qualification to lower FR levels. To extend qualification to FR level P, data shall be limited to each voltage group within a specification sheet.

c. Procedure III - Maintenance of FR level qualification. Maintenance period B of FRSP-10 shall apply. Regardless of the number of production lots produced during this period, the specified number of unit hours shall be accumulated to maintain qualification (see 4.6.1).

TABLE IV. Qualification inspection.

Inspection 1/	Requirement paragraph	Method paragraph	No. of sample units to be inspected	No. of failures allowed
Group I				
Voltage aging (exponential only, see 3.1)	3.6	4.7.3	178	N/A
DC leakage	3.7	4.7.4		
Capacitance	3.8	4.7.5		
Dissipation factor	3.9	4.7.6		
Visual and mechanical examination	3.4, 3.5, 3.21 and 3.22			
Group II				
Vibration, high frequency	3.10	4.7.7	12	1
Thermal shock	3.11	4.7.8		
Group III				
Resistance to soldering heat	3.12	4.7.9	18	
Terminal strength (when specified, see 3.1)	3.13	4.7.10		
Moisture resistance	3.14	4.7.11		
Group IV				
Stability at low and high temperatures	3.15	4.7.12	12	
Surge voltage (exponential only, see 3.1)	3.16	4.7.13		
Group V				
Life (at +125°C)	3.17	4.7.14	24	
Group VI				
Life (at +85°C) (failure rate)	3.17	4.7.14	102	1
Group VII				
Solderability	3.18	4.7.15	10	0
Resistance to solvents (when specified, see 3.1)	3.19	4.7.16		

1/ For qualification of design changes only, manufacturers may submit Weibull data instead of groups V and VI test data.

4.4.4.2 Weibull. Weibull FR qualification will be granted only to manufacturers who have achieved FR level P in accordance with 4.4.4.1. To extend qualification to include Weibull FR levels, the manufacturer shall demonstrate the capability of Weibull FR level grading (see 4.7.17), to the qualifying activity.

4.5 Verification of qualification. Every 6 months, the manufacturer shall compile a summary of the results of quality conformance inspections and, where applicable, extended FR test data, in the form of a verification of qualification report, and forward it to the qualifying activity as the basis of continued qualification approval. In addition to the periodic submission of FR test data, the manufacturer shall immediately notify the qualifying activity whenever the FR data indicates that the manufacturer had failed to maintain his qualified FR level. Continuation shall be based on evidence that, over the 6-month period, the following has been met:

a. Verification by the qualifying activity that the manufacturer meets the requirements of MIL-STD-790.

b. The manufacturer has not modified the design of the item. Change in design includes but is not limited to any change of materials or processes.

c. The specification requirements for the item have not been amended so as to affect the character of the item.

d. Lot rejection for group A does not exceed 5 percent or one lot, whichever is greater; not applicable to table VB.

e. Requirements for group C are met.

f. The records of all FR tests combined per style substantiate that the M, P, R, or S FR level has been maintained.

g. The records of all Weibull life FR tests are summarized for each specification sheet, stress level, and acceleration factor (see table VC).

If group C requirements were not met and the manufacturer has taken corrective action satisfactory to the Government, the forwarding of the verification of qualification report may be delayed until within 30 days after completion of retesting of the periodic quality conformance tests. In this case, the qualifying activity shall be notified of this condition within the time that the original verification of qualification report was due. All reports shall be certified by a responsible company official. The qualifying activity shall be contacted for the report format.

Failure to submit the report within 30 days after the end of each 6-month period may result in loss of qualification for the product. In addition to the periodic submission of inspection data, the supplier shall immediately notify the qualifying activity at any time during the 6-month period that the inspection data indicates failure of the qualified product to meet the requirements of the specification.

In the event that no production occurred during the reporting period, a report shall be submitted certifying that the company still has the capabilities and facilities necessary to produce the item. If during three consecutive reporting periods there has been no production, the manufacturer may be required, at the discretion of the qualifying activity, to submit a representative product of each style to testing in accordance with the qualification inspection requirements.

TABLE VA. Group A inspection (exponential distribution).

Inspection	Requirement paragraph	Test method paragraph	Quality levels (percent defective)
			All FR levels
Subgroup 1			
Voltage aging - - - - - -	3.6	4.7.3	100% inspection
			All FR levels
			Major / Minor
Subgroup 2			
Visual and mechanical inspection (external) - -	3.1, 3.4, 3.5, 3.21 and 3.22	4.7.2	1.0 (AQL) 7.6 (LQ) / 4.0 (AQL) 18.0 (LQ)
			All FR levels
Subgroup 3			
Stability at low and high temperatures - - - -	3.15	4.7.12	1.0 (AQL) 7.6 (LQ)
Subgroup 4			
Surge voltage - - - - - -	3.16	4.7.13	12 1/

1/ Twelve units from subgroup 3 samples to be submitted to this test, one failure allowed.

TABLE VB. Group A inspection (Weibull distribution).

Inspection 1/	Requirement paragraph	Test method paragraph	Quality levels (percent defective)		
			All FR levels		
			Major	Minor	
Subgroup 1					
Life (accelerated failure rate) 2/ - - - - - - - - -	3.20	4.7.17	100% inspection		
Subgroup 2					
Visual and mechanical inspection (external) - -	3.1, 3.4, 3.5, 3.21 and 3.22	4.7.2	1.0 (AQL) 7.6 (LQ)	4.0 (AQL) 18.0 (LQ)	
Subgroup 3			All FR levels		
Stability at low and high temperatures - - - -	3.15	4.7.12	Sample	Accept	Reject
			13 pcs.	1 failure	2 or more failures

1/ Sampling need only conform to requirements of 4.6.1.1.1 (exponential distribution).
2/ Exempt from 5% PDA; rejects shall not be delivered on the contract or order.

TABLE VC. Weibull grading failure rate summary.

Burn-in test voltage ____________________ Manufacturer ____________________

Voltage stress level ____________________ Location ____________________

Acceleration factor ____________________ Military style ____________________

Weibull inspection lot number	Nominal capacitance value	Rated dc volts	Quantity started	Date placed on test	Quantity of 2 hours initial failures	Quantity of end of test failures	Duration (real time test hours)	Beta	Z Rate %/K hours

4.6 Quality conformance inspection.

4.6.1 Inspection of product for delivery. Inspection of product for delivery shall consist of groups A and C inspections. However, shipment need not be held pending the results of group C tests.

4.6.1.1 Inspection lot.

4.6.1.1.1 Exponential distribution. An inspection lot shall consist of capacitors of the same specification sheet (see 3.1), from the same production line or lines, of the same basic design, produced under essentially the same conditions, and offered for inspection during a single month. Capacitors of the same specification sheet must be maintained to at least the P level. The capacitance values and voltages produced shall be represented in the lot in approximately the ratio of production. Voltage groups shall be as follows:

I - - - - - - - - - - - - - - - -	2 to 20 volts inclusive
II - - - - - - - - - - - - - - - -	25 to 50 volts inclusive

4.6.1.1.2 Weibull distribution. An inspection lot shall consist of capacitors of the same specification sheet (see 3.1), voltage rating, design, and nominal capacitance rating produced in the same case size. Manufacture of all parts in the lot shall have been started, processed, assembled, and tested as a group. Lot identity shall be maintained throughout the manufacturing cycle. All anodes shall be fabricated from a single identifiable powder lot.

4.6.1.2 Group A inspection. Group A inspection shall consist of the inspections specified in table VA or VB, and shall be made on the same set of sample units, in the order shown.

4.6.1.2.1 Sampling plan. Sampling shall be as specified in table VA or table VB. The sampling plan for subgroup 3 shall be in accordance with MIL-STD-105 for special inspection level S-4. Statistical sampling and inspection for subgroups 2 and 3 shall be in accordance with MIL-STD-105. The acceptable quality levels (AQL) and limiting quality (LQ) where P_a = 10% shall be as specified in table VA or table VB. At the option of the manufacturer, numerically lower AQL's may be used as long as the specified LQ is not exceeded numerically. Major and minor defects shall be as defined in MIL-STD-105 and as specified in table VA or VB. For exponential distribution:

a. The samples selected to form the lot shall be representative of the case sizes and voltage groups produced during the sampling period.

b. If, during the 100-percent inspection of subgroup 1 screening requires that over 5 percent of the capacitors be discarded, the lot shall be rejected and shall not be resubmitted. Defective units obtained from lots with less than 5 percent defective allowed (PDA) may be reworked and resubmitted only once.

c. A one-percent PDA shall apply to all resubmitted lots.

4.6.1.2.2 Manufacturer's production inspection. If the manufacturer performs tests similar to those specified in subgroup 1, table VA or table VB, as the final step of his production process, group A, subgroup 1 inspection may be waived and the data resulting from the manufacturer's production tests may be used instead. Authority to waive the subgroup 1 inspection shall be granted by the qualifying activity only. The following criteria shall be complied with:

a. Tests conducted by the manufacturer during production shall be clearly identical to or more stringent than that specified for subgroup 1. Test conditions shall be equal to or more stringent than those specified for subgroup 1.

b. Manufacturer subjects 100 percent of the products supplied under this specification to his production tests.

c. The parameters measured and the failure criteria shall be the same or more stringent than those specified herein.

d. The lot rejection criteria shall be the same or more stringent than that specified herein.

e. The manufacturer shall make available all information concerning the test procedures and instrumentation used in his production tests. This data shall be provided as part of the evaluation required for MIL-STD-790. The manufacturer shall also make available to the Government all records of all detail test data resulting from production tests.

f. Once approved, the manufacturer shall not change the test procedures or criteria without prior notification and concurrence by the qualifying activity.

4.6.1.2.3 Disposition of sample units. Sample units which have been subjected to subgroup 4 of group A inspection shall not be delivered on the contract or purchase order.

4.6.1.2.4 Rejected lots. Inspection lots rejected as a result of failure to pass subgroup 2 inspection may be resubmitted for Government acceptance only if the manufacturer performs 100-percent inspection on capacitors of the lot for those characteristics which were defective and resulted in rejection of lot, removes all defective units and resubmits the lot for quality conformance inspection. Inspection lots rejected as a result of failure to pass subgroup 3 or subgroup 4 shall not be resubmitted. Resubmitted lots shall be kept separate from new lots, and shall be clearly identified as resubmitted lots.

4.6.1.3 Group C inspection. Group C inspection shall consist of the tests specified in table VI, in the order shown. Group C inspection shall be made on sample units selected from inspection lots which have passed group A inspection; however, sample units subjected to surge voltage shall not be used.

4.6.1.3.1 Sampling plan. There shall be 89 sample units of each specification sheet taken from production every 2 months and subdivided as specified for the subgroups listed in table VI and subjected to the tests specified in those subgroups, in the order shown. The maximum and minimum case sizes manufactured during that month shall be represented in the sample in at least the approximate ratio of production. Allowable failures shall be as specified in table VI.

4.6.1.3.2 Disposition of sample units. Sample units which have been subjected to group C inspection shall not be delivered on the contract or order.

4.6.1.3.3 Noncompliance. If a sample unit fails to pass group C inspection, the supplier shall take corrective action on the materials or processes or both, as warranted, and on all units of product which can be corrected and which were manufactured under essentially the same conditions, with essentially the same materials, processes, etc., and which are considered subject to the same failure. Acceptance of the product shall be discontinued until corrective action, acceptable to the Government has been taken. After the corrective action has been taken, group C inspection shall be repeated on additional sample units (all inspections or the inspection that the original sample failed, at the option of the Government). Groups A and B inspections may be reinstituted; however, final acceptance shall be withheld until the group C reinspection has shown that the corrective action was successful. In the event of failure after reinspection, information concerning the failure and corrective action taken shall be furnished to the cognizant inspection activity and the qualifying activity.

4.6.2 Inspection of packaging. The sampling and inspection of the preservation, packing, and container marking shall be in accordance with the requirements of MIL-C-39028.

TABLE VI. Group C inspection.

Inspection	Requirement paragraph	Method paragraph	No. of sample units to be inspected	No. of failures allowed
Subgroup I				
Vibration, high frequency	3.10	4.7.7	12	1
Thermal shock	3.11	4.7.8		
Subgroup II				
Resistance to soldering heat	3.12	4.7.9	18	
Terminal strength (when specified, see 3.1)	3.13	4.7.10		
Moisture resistance	3.14	4.7.11		
Subgroup III				
Life (2,000 hrs at +125°C)	3.17	4.7.14	24	1
Subgroup IV				
Life (10,000 hrs at +85°C) FR (exponential only)	3.17	4.7.14.1	25 minimum per style	See 4.4.4.1
Subgroup V				
Solderability	3.18	4.7.15	10	0
Resistance to solvents (when specified, see 3.1)	3.19	4.7.16		0

4.7 Methods of inspection and test.

4.7.1 Mounting for testing. Mounting is optional for test environments; however, when specified in the test procedures, the chip capacitors shall be mounted on a suitable substrate (e.g., 96 percent alumina). The substrate material shall be such that it shall not be cause of, nor contribute to, failure of any test for which it may be used. The capacitors shall be mounted on the substrate as follows:

a. A substrate shall be prepared with metallized surface land areas of proper spacing to permit mounting of chips by soldering the terminations of the chips to the "test card" land areas.

b. Solder paste, type "R" or "RMA" in accordance with QQ-S-571, shall be applied to terminals or substrates as applicable.

c. The chip shall then be placed across the metallized land areas of the test substrate so as to make contact between chip and substrate land areas.

d. The substrate shall then be placed in or on a suitable heat transfer unit (molten solder, hot plate, tunnel oven, etc.,) with the temperature maintained at 260°C ±5°C for 2 minutes -0, +30 seconds, until the solder paste melts and reflows forming a homogeneous solder bond to the metallized substrate.

e. All excess flux or solder shall be removed.

4.7.2 Visual and mechanical inspection. Capacitors shall be examined to verify that the materials, design, construction, physical dimensions, marking, and workmanship are in accordance with the applicable requirements (see 3.4, 3.5, 3.21, and 3.22).

4.7.3 Voltage aging (exponential only) (see 3.6). Capacitors shall be subjected to a minimum of 100 percent of dc rated voltage for 40 hours, minimum, at a temperature of 85° ±5°C. The voltage aging circuit shall have a series resistance of 3.0 ohms, maximum. Capacitors shall then be stabilized at room temperature and the dc leakage, capacitance, and dissipation factor shall then be measured as specified in 4.7.4, 4.7.5, and 4.7.6, respectively.

4.7.4 DC leakage (see 3.7). DC leakage shall be measured using the dc rated voltage ±2 percent at the applicable test temperature (see 3.1), after a maximum electrification period of 5 minutes. A 1,000-ohm resistor shall be placed in series with the capacitor to limit the charging current. A steady source of power, such as a regulated power supply, shall be used. Unless otherwise specified (see 3.1), measurement accuracy shall be within ±2 percent or 0.02 microampere (μA), whichever is greater (see 4.3.3).

4.7.5 Capacitance (see 3.8). Capacitors shall be tested in accordance with method 305 of MIL-STD-202. Unless otherwise specified (see 3.1), the following details shall apply:

a. Test frequency: 120 ±5 hertz (Hz).

b. Limit of accuracy: Measurement accuracy shall be within ±2 percent of the reading.

c. Magnitude of polarizing voltage: Maximum dc bias shall be 2.2 volts for all ac measurements. The magnitude of the ac voltage shall be limited to 1.0 volt root mean square (rms).

4.7.6 Dissipation factor (see 3.9). The dissipation factor shall be measured at a frequency of 120 ±5 Hz (unless otherwise specified, see 3.1) by means of a polarized capacitance bridge. The bridge shall provide a dial reading accuracy of 0.1 percent dissipation factor and a measuring accuracy of ± (2 percent of the measured dissipation factor plus 0.1 percent).

4.7.7 Vibration, high frequency (see 3.10). Capacitors shall be tested in accordance with method 204 of MIL-STD-202. The following details and exceptions shall apply:

a. Mounting of specimens: Capacitors shall be mounted on a substrate as specified in 4.7.1.

b. Electrical-load conditions: During the test, the specified dc rated voltage (see 3.1) shall be applied to the capacitors.

c. Test condition letter: D (20 g).

d. Duration and direction of motion: 4 hours in each of two mutually perpendicular directions (total of 8 hours), one parallel and the other perpendicular to the axis.

e. Measurements during vibration: During the last cycle, an electrical measurement shall be made to determine intermittent operation or open- or short-circuiting. Observations shall also be made to determine intermittent contact or arcing or open- or short-circuiting. Detecting equipment shall be sufficiently sensitive to detect any interruption with a duration of 0.5 millisecond (ms), or greater.

f. Measurements after vibration: Not applicable.

g. Examination after test: Capacitors shall be visually examined for evidence of mechanical damage.

4.7.8 Thermal shock (see 3.11). Capacitors shall be tested in accordance with method 107 of MIL-STD-202. The following details and exception shall apply:

a. Mounting of specimens: Capacitors shall be mounted on a substrate as specified in 4.7.1.

b. Test condition letter: B.

c. Measurements after thermal shock: DC leakage, capacitance, and dissipation factor shall be measured as specified in 4.7.4, 4.7.5, and 4.7.6, respectively.

d. Examination after test: Capacitors shall be visually examined for evidence of harmful corrosion, mechanical damage, and obliteration of marking (if applicable).

4.7.9 Resistance to soldering heat (see 3.12). Capacitors shall be tested in accordance with method 210 of MIL-STD-202. The following details and exception shall apply:

a. Mounting of specimens: Capacitors shall be mounted on a substrate as specified in 4.7.1.

b. Test condition letter: E or B, as specified (see 3.1).

c. Cooling time prior to measurement after test: Not applicable.

d. Examination after test: Capacitors shall be visually examined for evidence of mechanical damage.

e. Depth of immersion in molten solder: Leads shall be immersed to within .250 inch of the case.

4.7.10 Terminal strength (when specified, see 3.1)(see 3.13). Capacitors shall be tested in accordance with method 211 of MIL-STD-202. The following details shall apply, unless otherwise specified (see 3.1):

a. Test condition letter: A, the body of the capacitor shall be secured; 0.5 pound applied force.

b. Test condition letter: C, 0.5 pound applied force.

After the test, capacitors shall be visually examined for loosening of the terminals and permanent damage to the terminals.

4.7.11 Moisture resistance (see 3.14). Capacitors shall be tested in accordance with method 106 of MIL-STD-202. The following details and exceptions shall apply:

a. Mounting of specimens: Capacitors shall be mounted on a substrate as specified in 4.7.1.

b. Initial measurements: Capacitance as specified in 4.7.5.

c. Number of cycles: 20 continuous cycles except that steps 7a and 7b shall be omitted.

d. Loading voltage: Not applicable.

e. Final measurements: After removal from chamber, capacitors shall be dried for 1 hour at room temperature and, within the next hour, dc leakage, capacitance, and dissipation factor shall be measured as specified in 4.7.4, 4.7.5, and 4.7.6, respectively.

f. Examination after test: Capacitors shall be visually examined for evidence of harmful corrosion, mechanical damage, and obliteration of marking (if applicable).

4.7.12 Stability at low and high temperatures (see 3.15). Capacitors shall be dried at +125°C for 30 +4, -0 minutes, prior to start of test. DC leakage, capacitance, and dissipation factor shall then be measured as specified in 4.7.4, 4.7.5, and 4.7.6, respectively, at each of the temperatures specified in table VII, except that dc leakage measurements at -55°C (step 2) are not required. The capacitors shall be brought to thermal stability at each test temperature. Thermal stability will have been reached when no further change in capacitance is observed between two successive measurements taken at 15 +2, -0 minute intervals.

TABLE VII. Temperature for stability test.

Step	Test temperature (°C)
1	+25 ±2
2	-55 +0, -3
3	+25 ±2
4	+85 +4, -0
5	+125 +4, -0
6	+25 ±2

4.7.13 Surge voltage (see 3.16). Capacitors shall be subjected to 1,000 cycles of the applicable surge voltage specified in table I. The ambient temperature during cycling shall be +85° ±5°C. Each cycle shall consist of a 30 +2, -0 second surge voltage application followed by a 30 +2, -0 second discharge period. Voltage application shall be made through a resistor of 33 ohms. The tolerance of the resistor shall be ±5 percent. Each surge voltage cycle shall be performed in such a manner that the capacitor is shorted terminal to terminal through a copper bar, or an

equivalent low resistance at the end of the 30 +2, -0 second application. An alternate method of shorting the capacitors is discharge through the same resistance that is utilized for charging. After the final cycle, the capacitors shall be stabilized at the inspection conditions specified in 4.3, and the dc leakage, capacitance, and dissipation factor shall be measured as specified in 4.7.4, 4.7.5, and 4.7.6, respectively.

4.7.14 Life (see 3.17). Capacitors shall be tested in accordance with method 108 of MIL-STD-202. The following details and exceptions shall apply:

a. Method of mounting: As specified in 4.7.1.

b. Test temperature and tolerance:

(1) For qualification: Capacitors being subjected to the test of group V of table IV shall be tested at +125° +4, -0°C. Capacitors being subjected to the test of group VI of table IV shall be tested at +85° +4, -0°C.

(2) For group C (2,000-hour proof): Capacitors shall be tested at +125° +4, -0°C.

c. Operating conditions: DC rated voltage (see 3.1) or derated voltage at +125°C (see table I), as applicable, shall be applied gradually (not to exceed 5 minutes either by a slow buildup of the voltage or through a resistor which shall be shorted out within 5 minutes). Voltage shall be applied continuously, except for measurement periods. The impedance of the voltage source, as seen from the terminals of each capacitor, shall not exceed 3 ohms. Storage batteries or an electronic power supply capable of supplying at least 1 ampere when a capacitor is shorted shall be used.

d. Test condition letter: F (2,000 hours).

e. Measurements during exposure: DC leakage at the applicable high test temperature shall be measured as specified in 4.7.4 at 0; 240 +48, -0 hours; 1,000 +48, -0 hours; and 2,000 +72, -0 hours.

f. Measurements after exposure: Capacitors shall be returned to the inspection conditions specified in 4.3, and visually examined for evidence of mechanical damage; dc leakage, capacitance, and dissipation factor shall then be measured as specified in 4.7.4, 4.7.5, and 4.7.6, respectively.

4.7.14.1 Extended life (exponential only). Capacitors shall be tested as specified in 4.7.14, except the test temperature shall be +85° +4, -0°C, and the duration of test shall be 10,000 hours. DC leakage shall be measured as specified in 4.7.4 at +85°C at 0; 240 +48, -0 hours; 1,000 +48, -0 hours; 2,000 +72, -0 hours; and every 2,000 hours thereafter until 10,000 +96, -0 hours have elapsed. Final measurements shall be in accordance with 4.7.14f.

4.7.15 Solderability (see 3.18). Capacitors shall be tested in accordance with method 208 of MIL-STD-202. Mounting surfaces shall be dipped to cover the normal mounting surfaces. After the test, the metallized edges shall be examined.

4.7.16 Resistance to solvents (when specified, see 3.1)(see 3.19). Capacitors shall be tested in accordance with method 215 of MIL-STD-202. The following exceptions shall apply:

a. Brushing is not required.

b. Measurements after test: DC leakage, capacitance, and dissipation factor shall be measured as specified in 4.7.4, 4.7.5, and 4.7.6, respectively.

4.7.17 Weibull FR level grading (see 3.20). Capacitors shall be tested in accordance with method 108 of MIL-STD-202. The following details and exception shall apply:

a. Distance of temperature from specimens, in inches: Not applicable.

b. Method of mounting: Capacitors shall be mounted by their terminations.

c. Test temperature and tolerance: +85°C +4°, -0°C.

d. Operating conditions: Accelerated dc voltage as applicable (see table VIII), shall be applied gradually (not to exceed 5 minutes by a slow buildup of the voltage). Maximum acceleration, 20,000:1. Voltage shall be applied continuously, except for failure count periods. The impedance of the voltage source, as seen from the terminals of each capacitor, shall not exceed one ohm. An electronic power supply capable of supplying at least 5 amperes when a capacitor is shorted shall be used.

e. Minimum sample size for monitoring at beginning of test prior to infant mortal period: 300 pieces, or 100 percent, whichever is less.

f. Duration of test: 40 hours minimum.

Timing: Infant mortal period X_1 X_2

0	15 minutes maximum	2 hours minimum	40 hours minimum

g. Failure definition: A failure is defined as a blown fuse or equivalent.

h. Failure count during test: The lot size (see 4.6.1.1.2) to be graded is established after removal of gross defectives (infant mortality) (15 minutes maximum). The first failure count shall be performed at least 2 hours after the test was started. The number of blown fuses and the time under test shall be recorded to within ±0.1 hour. Calculate the fraction failed, p_1, at time, x_1, see equation 4 (6.7.2). Optionally, MIL-STD-690, table II FRSP-90 may be used to compute the failure rate base on the accelerated part hours generated when C = 0, (see examples A and B, 6.7.2).

i. Failure count after test: A failure count shall be performed after 40 hours minimum after the test was started. The number of blown fuses and the time under test shall be recorded to within ±0.1 hour. Calculate the cumulative fraction failed, p_2, at time, x_2, see equation 4 (6.7.2).

j. Lot failure rate: Determine Z (t) from equation 3 (6.7.1). If the desired failure rate has been achieved, the lot may be removed from test.

k. Continuation grading: If the desired failure rate has not been reached, the lot may be continued on test. The time to reach the failure rate goal may be determined from equation 5 (6.7.2). If the time calculated to reach the goal failure rate is excessive, the lot may be discarded in favor of a new lot.

l. Measurements after exposure: Capacitors shall be removed from the test, be stabilized at room ambient conditions (see 4.3) and the dc leakage, capacitance and dissipation factor, shall be measured as specified in 4.7.4, 4.7.5, and 4.7.6, respectively.

5. PACKAGING

5.1 Packaging requirements. The requirements for packaging shall be in accordance with MIL-C-39028.

6. NOTES

6.1 Intended use. Tantalum chip capacitors are intended to be used in thin or thick film hybrid circuits where microcircuitry is indicated. They are not intended for replacement purposes, therefore, no interchangeability or substitution data are offered.

6.2 Ordering data. Acquisition documents should specify the following:

6.2.1 Acquisition requirements.

a. Title, number, and date of this specification.

b. Title, number, and date of the applicable specification sheet, and the complete type designation (see 3.1).

6.3 Qualification. 2/ With respect to products requiring qualification, awards will be made only for products which are at the time set for opening of bids, qualified for inclusion in the applicable qualified products list, whether or not such products have actually been so listed by that date. The attention of the suppliers is called to this requirement, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government, tested for qualification, in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. The activity responsible for the qualified products list is US Army Laboratory Command; however, information pertaining to qualification of products may be obtained from the Defense Electronics Supply Center (DESC-E), 1507 Wilmington Pike, Dayton, Ohio 45444.

6.4 Standard capacitor types. Equipment designers should refer to MIL-STD-198, "Capacitors, Selection and Use of," for standard capacitor types and selected values chosen from this specification. MIL-STD-198 provides a selection of standard capacitors for new equipment design.

6.5 Supersession data. Capacitors of this specification unilaterally supersede the capacitor types and styles of equivalent capacitance, capacitance tolerance, voltage rating, case size, and failure rate level covered under MIL-C-55365A (see 3.1). For failure rate levels B, C, D, and E the superseding specification changes the method for calculating failure rate. The reliability of the capacitors made against the specification has not changed. The superseding specification requires lot-by-lot assessment of failure rate in place of a statistical process average. Qualified manufacturers may mark exponential failure rate dash numbers on parts that have been Weibull graded to levels B, C, D, or E. Items having a Weibull failure rate level (FRL) may be substituted for items of an exponential FRL as shown in table VIII. Weibull FR determination is based on lot by lot 100% quality conformance accelerated failure rate life testing. For example:

2500	capacitors have a voltage rating (V_r) of 50 V dc.
X40	hours Weibull life test at 65 V dc. voltage applied (V_a).
X279.1496	acceleration factor for V_a/V_r = 1.3000.
27,914,960	accelerated part hours.

2/ SD-6, "Provisions Governing Qualification," is issued for the information of applicants requesting qualification of products. Copies of this publication may be obtained from the Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120.

Weibull FRLs are determined from actual lot performance data. Exponential FRL determination starts with several production lots which may be included in the same inspection lot. For example, 4 production lots of 2,500 capacitors have a voltage rating of 50 V dc are offered for inspection in the same inspection lot.

10,000	capacitors with a voltage rating (V_r) of 50 V dc.
X40	hours voltage conditioning at 50 V dc minimum.
400,000	part hours, however, exponential lot voltage conditioning performance data are not used to determine FRLs.
110	samples are drawn from the inspection lot of 10,000 capacitors.
X2000	hours group C life test at 50 V dc voltage applied.
220,000	part hours, however, data accumulated and used to determine FRLs.
10	samples selected upon completing each group C inspection.
X9760	hours continuation life testing to 10,000 hours.
97,600	rated condition part hours for FRL maintenance.

Exponential FRLs are based on the aggregate averages of a few samples drawn from many lots maintained in accordance with MIL-STD-690.

TABLE VIII. Failure rate level substitutability.

Parts qualified to failure rate level	Are substitutable for failure rate level
D	M, P, R, S, B, and C
C	M, P, R, S, and B
B	M, P, R, and S
S	M, P, and R
R	M and P
P	M

6.6 Soldering heat. Caution should be exercised when subjecting these units to soldering heat. Preheat and soldering exposure times and temperatures should be held to a minimum.

6.7 Weibull FR level determination. Time ordered distribution of failures for solid tantalum capacitors is described by the Weibull equation:

Equation 1

$$F(x) = 1 - \exp\left[-\frac{x^{\beta}}{\alpha}\right]$$

Where: $F(x)$ = cumulative fraction failed (p) at time x
x = actual test time
β = Weibull "shape parameter" (beta)
α = Weibull "scale parameter"

This relationship may be plotted on graph paper which is constructed with ln x as abscissae and ln ln $\frac{1}{(1-p)}$ as ordinates. Auxiliary scales allow plotting x and p directly. A straight line is obtained. The slope of this line is β, and the y-intercept is $-\ln \alpha$. Figure 1 illustrates a typical Weibull plot.

At any time x, values for β and p can be obtained and the lot failure rate Z (x) may be calculated from Equation 3. A second plot of failure rate versus time may be drafted as indicated on figure 2. The slope of this line is β-1. Acceptable capacitor lots always exhibit decreasing failure rate with respect to time as evidenced by a value of β which is less than unity.

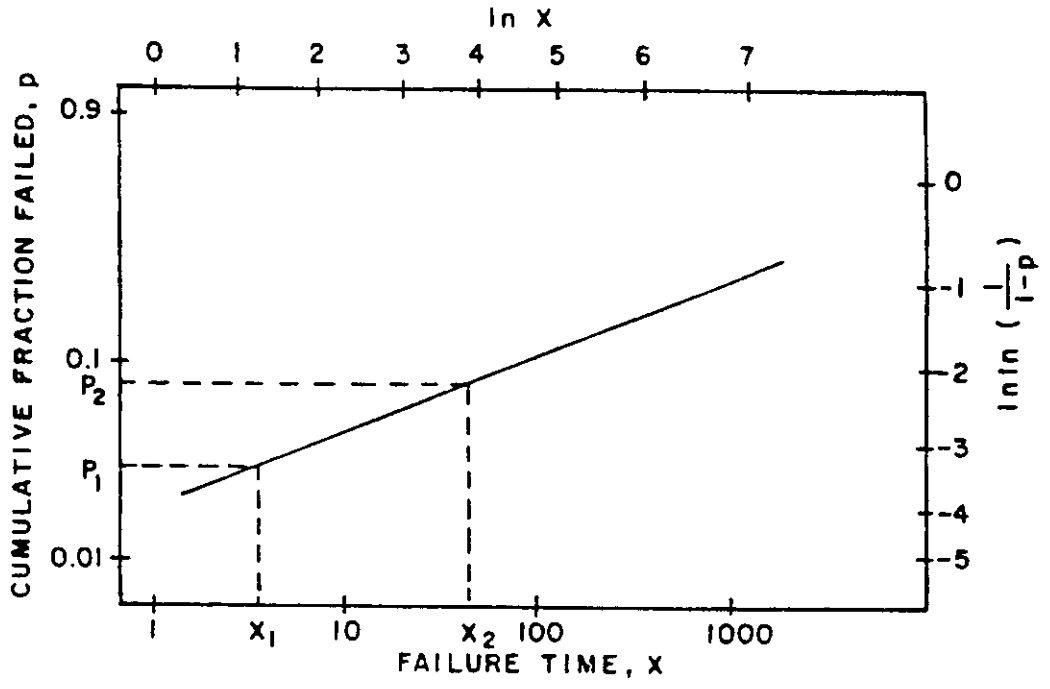

FIGURE 1. Typical Weibull plot.

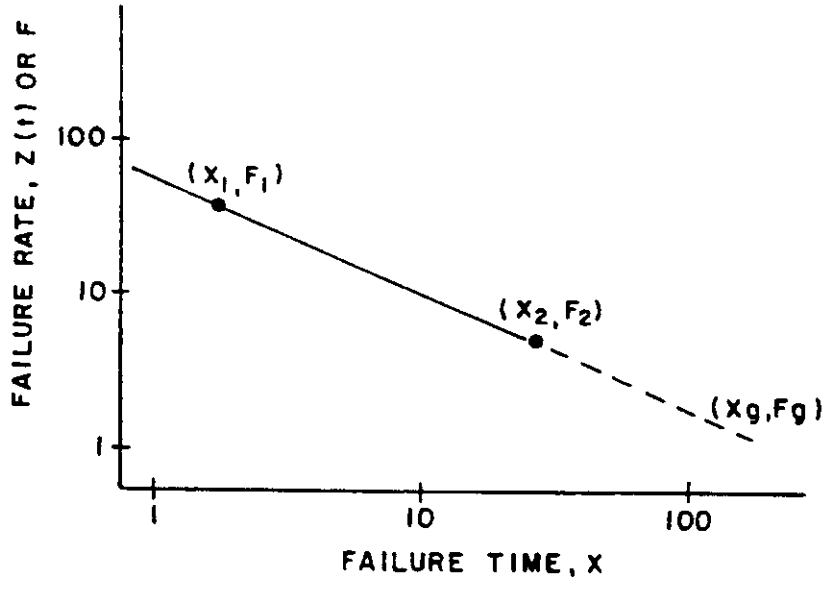

FIGURE 2. Failure rate versus time.

6.7.1 Acceleration factors. In order to provide the equivalent of several thousand hours of testing within a practical time frame, voltage acceleration is employed. It has been determined that the application of voltage in excess of rated voltage produces a higher failure rate than that observed when the devices are operated at the nominal voltage rating. On the Weibull plot, a straight line, parallel to the line representing rated voltage is obtained. The increased number of failures indicated by the line representing the higher voltage results from increased dielectric stress. The slopes (β) of both lines are essentially the same, but the time (x) required to produce any specified p is reduced as voltage is increased. As a result, acceleration factors may be specified which define the relationship between operation at rated voltage and operation at higher-than-rated voltages. For example, a lot of capacitors having a voltage rating of 50 V dc might be tested at 65 V dc. In this case, the ratio of applied voltage to rated voltage is 1.30, resulting in an acceleration factor (A) of 279. In practical terms, operation of these capacitors for 1 hour at 65 V dc is equivalent to operation at 50 V dc for 279 hours. This relationship may be mathematically represented as:

Equation 2

$$Z(t) = Z(Ax) = \frac{\beta}{\alpha} x^{\beta-1} \cdot \frac{1}{A}$$

In conjunction with Equation 1, this function may be restated as:

Equation 3

$$Z(t) = F = \frac{-\beta \ln(1-p)}{x} \cdot \frac{10^5}{A}$$

The 10^5 factor allows for expression of Z(t) in terms of percent per 1,000 hours when x denotes hours. Table IX illustrates a range of acceleration factors normally used for Weibull FR determination.

6.7.2 Grading calculations. On the basis of failure counts at x_1 and x_2 as specified in 4.7.1.7, the slope between these points is calculated as follows:

Equation 4

$$\beta = \frac{\ln\ln\left(\frac{1}{1-p_2}\right) - \ln\ln\left(\frac{1}{1-p_1}\right)}{\ln x_2 - \ln x_1}$$

The failure rate at time x_2 is then determined from Equation 3:

$$F_2 = \frac{-\beta \ln (1-p_2) \times 10^5}{x_2 A}$$

If additional grading time is required to reach the desired failure rate, the required time x_g may be determined as follows:

Equation 5

$$\ln x_g = \frac{\ln F_g - \ln F_2}{\beta - 1} + \ln x_2$$

Equation 6

$$A = 7.03412025 \times 10^{-9} \; e^{18.77249321 \times \frac{V_a}{V_r}}$$

A = Acceleration factor
e = Natural logarithm
V_a = Accelerated voltage
V_r = Rated voltage

TABLE IX. Nominal acceleration factors.

Grading stress V_a/V_r 1/	Accelerated factor
1.0000	1.0000
1.1000	6.5355
1.2000	42.7128
1.3000	279.1496
1.4000	1,824.3823
1.5000	11,923.2626
1.5276	20,000.0000

1/ V_a = accelerated voltage;
V_r = rated voltage.

Examples: A. 880 capacitors tested at a grading stress level of 1.2300 (75.0139 acceleration factor) for 40 hours resulted in zero failures.

880 (75.0139 x 40) = 2,640,489 hours
C = 0
FR = B level (MIL-STD-690 FRSP-90)

B. 1,350 capacitors tested at a grading stress level of 1.3300 (490.2535 acceleration factor) for 40 hours resulted in zero failures.

1,350 (490.2535 x 40) = 26,473,689 hours
C = 0
FR = C level (MIL-STD-690 FRSP-90)

C. 400 capacitors tested at a grading stress level of 1.4000 (1824.3823 acceleration factor) for 40 hours resulted in 1 failure at x_1; no additional failures at x_2.

400 (1824.3823 x 40) = 29,190,117 hours
C = 1
FR = B level (MIL-STD-690 FRSP-90)

D. 100 capacitors tested at a grading stress level of 1.4000 (1824.3823 acceleration factor) for 41 hours resulted in 3 failures at x_1; no additional failures at x_2.

100 (1824.3823 x 41) = 7,479,967.430
C = 3
FR = B level (MIL-STD-690 FRSP-90)

OR assume one additional failure at x_2

x_1 = 2 hours
x_2 = 41 hours
p_1 = .03
p_2 = .04
A = 1824.3823

$$\beta = \frac{\ln \ln \frac{1}{1-p_2} - \ln \ln \frac{1}{1-p_1}}{\ln x_2 - \ln x_1}$$

$$= \frac{\ln \ln \frac{1}{1-.04} - \ln \ln \frac{1}{1-.03}}{\ln 41 - \ln 2}$$

$$= \frac{\ln \ln 1.041666 - \ln \ln 1.030928}{3.713572-0.693147}$$

$$= \frac{-3.1985499 - (-3.4913617)}{3.02042425}$$

$$= \frac{0.2928118}{3.02042425} = 0.096944$$

$$FRL = \frac{-\beta \ln (1-p_2)10^5}{x_2 A} = \frac{-0.096944 \ln (.96)10^5}{41\ (1824.3823)}$$

$$= \frac{-0.096944\ (-0.040822)10^5}{74799.67} = 0.000000053 \times 10^5$$

$$= \frac{0.0053\%}{1{,}000 \text{ hours}}$$

To compute hours needed to verify 0.001% per 1,000 hours FRL:

$$\ln x_g = \frac{\ln F_g - \ln F_2}{\beta - 1} + \ln x_2$$

x_2 = hours at point 2
x_g = hours to test (goal)
F_2 = observed FRL at x_2
F_g = Failure rate level (goal)

$$\ln x_g = \frac{\ln (0.001) - \ln (0.0053)}{-0.903056} + \ln 41$$

$$= \frac{-6.9077553 - (-5.2400485)}{-0.903056} + 3.713572$$

$$= \frac{-1.6677068}{-0.903056} + 3.713572$$

$$= 1.8467369 + 3.713572 = 5.5603089$$

$$x_g = 259.90 \text{ hours}$$

6.7.3 Weibull grading method. After determining the lot failure rate per 4.7.17 the balance of the lot (when applicable) should be tested to the same voltage acceleration conditions as the monitored test samples. These units shall then be subjected to the 100-percent electrical tests shown in table VB.

6.8 Subject term (key word) listing.

Capacitor
Chip
Established reliability
Tantalum
Weibull

6.9 Changes from previous issue. Asterisks are not used in this revision to identify changes with respect to the previous issue, due to the extensiveness of the changes.

APPENDIX A

PROCEDURES FOR QUALIFICATION INSPECTION

10. SCOPE

10.1 This appendix details the procedures for submission of samples, with related data, for qualification inspection of capacitors covered by this specification. The procedures for extending qualification of the required sample to other capacitors covered by this specification are also outlined herein.

20. SUBMISSION

20.1 Sample.

20.1.1 Single-style submission. A sample consisting of sample units of the highest capacitance value in each voltage group in each style for which qualification is sought shall be submitted (see table X).

TABLE X. Combined-voltage submission.

Style	Type designation 1/	Number of units	Rated voltage
CWR03 and CWR04	CWR0-B-107-M	89	3
	CWR0-J-226-M	89	20
	CWR0-M-106-M	89	35
	CWR0-N-335-M	89	50
CWR06	CWR06C-107-M	89	4
	CWR06J-226-M	89	20
	CWR06K-156-M	89	25
	CWR06N-475-M	89	50

1/ Where applicable, complete type designation will include additional symbols to indicate style, termination finish, and capacitance tolerance.

20.2 Certification of material. When submitting samples for qualification, the supplier shall submit certification, in duplicate, that the materials used in his components are in accordance with the applicable specification requirements.

20.3 Description of items. The contractor shall submit a detailed description of the capacitors being submitted for inspection, including body, coating, electrode material, terminal leads, etc.

30. EXTENT OF QUALIFICATION

30.1 Single-style submission. Capacitance-range qualification will be restricted to values equal to and less than the capacitance value submitted. Capacitance-tolerance qualification will be restricted to tolerances equal to and wider than the tolerance submitted. Voltage rating qualification will be restricted to that submitted.

30.2 Combined-voltage submission. Capacitance-range qualification will be restricted to values equal to and less than the capacitance value submitted. Capacitance-tolerance qualification will be restricted to tolerances equal to and wider than the tolerance submitted. Voltage rating qualification will be restricted to those submitted.

APPENDIX B

PROCEDURES FOR QUALIFICATION INSPECTION
(WEIBULL DISTRIBUTION)

10. SCOPE

10.1 Weibull FR level qualification. Weibull failure rate qualification will be extended only to manufacturers who have achieved the P level failure rate in accordance with 4.4.4. To extend qualification to include Weibull failure rate level, the manufacturer shall certify and demonstrate the capability of Weibull FR level grading (see 4.7.17) to the qualifying activity.

10.2 Weibull qualification sample submission. A sample consisting of 89 sample units of the highest capacitance value in 50- and 20-volt ratings (35- and 15-volt ratings for CWR10) in each case size for each specification sheet for which qualification is sought shall be submitted.

Custodians:
Army - ER
Navy - EC
Air Force - 85

Review activities:
Navy - SH
Air Force - 17, 99
DLA - ES

User activities:
Navy - AS, CG, MC, OS
Air Force - 11, 19

Preparing activity:
Army - ER

Agent:
DLA - ES

(Project 5910-1561)

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a. Paragraph Number and Wording:

b. Recommended Wording:

c. Reason/Rationale for Recommendation:

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